SECURITY INFORMATION

[redacted] UNCLASSIFIED

Copy 44
RM SL51J31

RA A23L101

NACA

RESEARCH MEMORANDUM

for the

Bureau of Aeronautics, Department of the Navy

FREE-SPINNING TUNNEL INVESTIGATION OF THE $\frac{1}{21}$-SCALE

MODEL OF THE CHANCE VOUGHT F7U-3 AIRPLANE

TED NO. NACA DE 362

By Walter J. Klinar and Frederick M. Healy

Langley Aeronautical Laboratory
Langley Field, Va.

CLASSIFICATION CHANGED

UNCLASSIFIED

To ____________

By authority TPA #45 Date 4/13/61

CLASSIFIED DOCUMENT

NATIONAL ADVISORY COMMITTEE
FOR AERONAUTICS

WASHINGTON

NOV 9 1951

[redacted]

UNCLASSIFIED

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

RESEARCH MEMORANDUM

for the

Bureau of Aeronautics, Department of the Navy

FREE-SPINNING TUNNEL INVESTIGATION OF THE $\frac{1}{21}$-SCALE MODEL OF THE CHANCE VOUGHT F7U-3 AIRPLANE

TED NO. NACA DE 362

By Walter J. Klinar and Frederick M. Healy

SUMMARY

An investigation of a $\frac{1}{21}$-scale model of the Chance Vought F7U-3 airplane has been conducted in the Langley 20-foot free-spinning tunnel. The erect and inverted spin and recovery characteristics of the model were determined for the combat loading with the model in the clean condition. The effect of extending slats and speed brakes and the effect of variation in loading was investigated. Spin-recovery parachute tests were also performed.

The results indicate that any erect spin obtained on the airplane in the clean condition will be satisfactorily terminated for all loading conditions indicated as possible provided rudder reversal is accompanied by moving the ailerons to full with the spin (stick right in a right spin). Although not specifically tested in this investigation, previous experience on an earlier version of this airplane indicates that, with external stores installed, the same recovery technique should be used. If recovery does not appear imminent when a spin is entered with external stores installed, however, the external stores should be jettisoned and recovery reattempted. Extension of slats should have a favorable effect whereas extension of the dive brakes should have little effect on the spin-recovery characteristics. Inverted spins should be satisfactorily terminated by full reversal of the rudder and lateral and longitudinal neutralization of the stick. The model test results indicate that a 6.12-foot wing-tip conventional parachute (drag coefficient approximately 0.7) should be effective as an emergency spin-recovery device during demonstration spins of the airplane.

[redacted]

INTRODUCTION

At the request of the Bureau of Aeronautics, Navy Department, a spin investigation has been made in the Langley 20-foot free-spinning tunnel of a $\frac{1}{21}$-scale model of the Chance Vought F7U-3 airplane. The F7U-3 differs from the Chance-Vought XF7U-1 airplane investigated in the spin tunnel and reported in reference 1 primarily in that the ailavators (the surfaces used for lateral and longitudinal control) are larger and deflect farther, the wing and vertical tail surfaces are larger, and the fuselage is moved forward with respect to the wing. Auxiliary rudders mounted below the main rudders on the vertical tail have also been incorporated into the F7U-3 design. References 2 and 3 present the results of investigations conducted in the spin tunnel on models of the earlier versions of the XF7U-1 airplane.

The erect and inverted spin and recovery characteristics of the model in the combat loading were determined. The effect of deflecting slats, speed brakes and auxiliary rudders was also determined. The investigation included parachute-recovery tests and tests to determine the effect of loading variation.

SYMBOLS

b	wing span, feet
m	mass of airplane, slugs
$\bar{c}$	mean geometric chord, inches
$x/\bar{c}$	ratio of distance of center of gravity rearward of leading edge of mean geometric chord to mean geometric chord
$z/\bar{c}$	ratio of distance between center of gravity and wing root chord line to mean geometric chord (positive when center of gravity is below root chord line)
I_X, I_Y, I_Z	moments of inertia about X-, Y-, and Z-body axes, respectively, slug feet^2
$\frac{I_X - I_Y}{mb^2}$	inertia yawing-moment parameter

$\frac{I_Y - I_Z}{mb^2}$ inertia rolling-moment parameter

$\frac{I_Z - I_X}{mb^2}$ inertia pitching-moment parameter

ρ air density, slug per cubic foot

α angle between root chord line and vertical (approximately equal to absolute value of angle of attack at plane of symmetry), degrees

ϕ angle between wing-span axis and horizontal, degrees

V full-scale true rate of descent, feet per second

Ω full-scale angular velocity about spin axis, revolutions per second

APPARATUS AND METHODS

Model

The $\frac{1}{21}$-scale model of the Chance Vought F7U-3 airplane used for the tests was furnished by the Bureau of Aeronautics and was prepared for testing by the Langley Laboratory of the National Advisory Committee for Aeronautics. A three-view drawing of the model as tested is shown in figure 1. Photographs of the model are shown in figures 2, 3, and 4. The dimensional characteristics of the airplane are presented in table I.

The model was ballasted to obtain dynamic similarity to the airplane at an altitude of 15,000 feet (ρ = 0.001496 slug/cu ft). A remote-control mechanism was installed in the model to actuate the controls for the recovery attempts. Sufficient hinge moments were exerted on the controls for the recovery attempts to reverse them fully and rapidly.

The main rudders of the model, the large span rudders mounted high on the vertical tail as shown in figures 1 and 3, were linked to move simultaneously and were connected to the control-actuating mechanism. These rudders are manually operated on the F7U-3 airplane. The auxiliary rudders shown below the main rudders in figures 1 and 3 have the following uses on the airplane: serve as a manual directional trimming control; operate automatically as the autopilot directional control; provide artifical damping in yaw; or, when slats are extended, provide artificial static directional stability. On the airplane all four functions of the auxiliary rudders may be superimposed one on the other. On the model, the auxiliary rudders were preset at certain fixed conditions and were not moved during the model steady spins and recoveries.

Longitudinal and lateral control of the airplane and model is obtained from deflection of one set of control surfaces called ailavators. Hereinafter, aliavator deflections for longitudinal and lateral control will be referred to, for simplicity, as elevator deflection and aileron deflection, respectively.

Wind-Tunnel and Testing Technique

The tests were performed in the Langley 20-foot free-spinning tunnel, the operation of which is generally similar to that described in reference 4 for the Langley 15-foot free-spinning tunnel except that the model-launching technique has been changed. With the controls set in the desired position, the model is launched by hand with rotation into the vertically rising air stream. After a number of turns in the established spin, the recovery attempt is made by moving one or more controls by means of the remote-control mechanism. After recovery, the model dives into a safety net. The spin data obtained from these tests are then converted to corresponding full-scale values by methods also described in reference 4.

In accordance with standard spin-tunnel procedure, tests were performed to determine the spin and recovery characteristics of the model for the normal spinning-control configuration (elevator full up, ailerons neutral, and rudder full with the spin) and for various other aileron-elevator combinations including neutral and maximum settings of the surfaces for various model loadings and configurations. Recovery was generally attempted by rapid reversal of the main rudders from full with to full against the spin. Tests were also performed to evaluate the possible adverse effects on recovery of small deviations from the normal control configuration for spinning. For these tests, the elevator was set at either full up or two-thirds of its full-up deflection and the ailerons were set at one-third of full deflection in the direction conducive to slower recoveries (against the spin for the F7U-3 model for all loadings). Recovery from this spin was attempted either by rapidly reversing the rudders from full with to only two-thirds against the spin or by simultaneous reversal of the rudders to two-thirds against the spin and movement of the ailerons to full with the spin. These control configurations and manipulations are referred to as the "criterion spin."

Turns for recovery are measured from the time the controls are moved, or the parachute opened, to the time the spin rotation ceases. The criterion for a satisfactory recovery from a spin for the model has been adopted as $2\frac{1}{4}$ turns or less, based primarily on the loss of altitude of the airplane during the recovery and subsequent dive. Recovery characteristics of the model may be considered satisfactory if recovery attempted from the criterion spin in the manner previously described requires only $2\frac{1}{4}$ turns.

For the spins which had a rate of descent in excess of that which can readily be obtained in the tunnel, the rate of descent was recorded as greater than the velocity at the time the model hit the safety net, for example, >300 feet per second full scale. For these tests, the recovery was attempted before the model reached its final steeper attitude and while the model was still descending in the tunnel. Such results are considered conservative; that is, recoveries will not be as fast as when the model is in the final steeper attitude. For recovery attempts in which the model struck the safety net while it was still in a spin, the recovery was recorded as greater than the number of turns from the time the controls were moved to the time the model struck the safety net, as >3. A >3 turn recovery, however, does not necessarily indicate an improvement over a >7 turn recovery. When the model recovered without control movement (rudder with the spin) the results were recorded as "no spin." For recovery attempts for which the model did not recover within 10 turns, the recovery was recorded as ∞.

For the spin-recovery parachute tests, the minimum size wing-tip parachute required to effect recovery within $2\frac{1}{4}$ turns from the criterion spin was considered satisfactory. Tail parachutes were not investigated on this model because the required tail parachute would probably be excessively large due to the short tail length of this design and also because of the likelihood of a tail parachute fouling on the twin tails. For these tests, the parachute was opened for the recovery attempts by actuating the remote-control mechanism and the main rudders were held with the spin so that recovery was due entirely to the parachute action alone. The wing-tip parachutes were attached to the outer wing tip (left wing in a right spin) just in front of the ailavator hinge line. The folded wing-tip parachute was placed on the wing in such a position that it did not seriously influence the established spin. For the model tests, a rubber band holding the packed parachute to the wing was released and the parachute was opened merely by the action of the air stream. On the full-scale parachute installation it would be desirable to mount the parachute pack within the airplane structure, and it is recommended that a positive ejection mechanism be employed to open the parachute.

PRECISION

The spin results presented herein are believed to be the true values given by the model within the following limits:

α, deg	±1
ϕ, deg	±1
V, percent	±5
Ω, percent	±2
Turns for recovery	±1/4 turn when obtained from motion-picture records ±1/2 turn when obtained by visual estimate

The preceding limits may have been exceeded for certain spins in which it was difficult to control the model in the tunnel because of the high rate of descent or because of the wandering or oscillatory nature of the spin.

Comparison between model and full-scale results in reference 5 indicated that model tests satisfactorily predicted full-scale recovery characteristics approximately 90 percent of the time and that for the remaining 10 percent of the time, the model results were of value in predicting some of the details of the full-scale spins. The airplanes generally spun at an angle of attack closer to 45° than did the corresponding models. The comparison presented in reference 5 also indicated that generally the airplanes spun with the inner wing tilted more downward and with a greater altitude loss per revolution than did the corresponding models.

Because it is impracticable to ballast the model exactly and because of inadvertent damage to the model during tests, the measured weight and mass distribution of the F7U-3 model varied from the true-scaled down values within the following limits:

Weight, percent	0 to 1 high
Center-of-gravity location, percent $\bar{c}$	0
Moments of inertia: I_X, percent	0 to 8 high
Moments of inertia: I_Y, percent	0 to 4 high
Moments of inertia: I_Z, percent	4 low to 1 high

The accuracy of measuring the weight and mass distribution of the model are believed to be within the following limits:

Weight, percent	±1
Center-of-gravity location, percent $\bar{c}$	±1
Moments of inertia, percent	±5

Controls were set with an accuracy of $\pm 1^{\circ}$.

TEST CONDITIONS

Tests were performed for the model conditions listed in table II. For all tests, the landing gear was retracted and the cockpit was closed. As is indicated in table II, and as has been indicated previously, the auxiliary rudders on the model did not operate automatically as they do on the airplane but were set to and maintained at a given setting during the model spin. Mass characteristics and mass parameters for the combat loading condition and for the other loading conditions possible on the airplane as well as for the loadings tested on the model are listed in table III.

The mass-distribution parameters for the loadings possible on the F7U-3 airplane and for the loadings tested on the model are plotted in figure 5. As discussed in reference 6, figure 5 may be used as an aid in predicting the relative effectiveness of the controls on the recovery characteristics of the model.

The normal maximum control deflections used in the tests (measured perpendicular to the hinge lines) were

Main rudders, deg	22.75 right, 22.75 left
Auxiliary rudders, deg	21.7 right, 21.7 left
Elevator, deg	32.4 up, 11 down
Ailerons, deg	32.4 up, 32.4 down

A diagram of stick against ailavator position is shown in figure 6.

RESULTS AND DISCUSSION

The results of the model spin tests are presented in charts 1 to 4 and in table IV. Inasmuch as the results to the right and left were similar, the data are arbitrarily presented in terms of right spins.

Erect Spins

Clean condition - combat loading.- Chart 1 presents the results of tests for the combat loading (loading point 1 on table III and fig. 5) with the model in the clean condition for various fixed positions of the auxiliary rudders.

With the auxiliary rudders maintained at neutral, the model did not spin for neutral and with-the-spin (stick right in a right spin) settings of the ailerons; however, spins were obtainable when the ailerons were placed against the spin. It should be noted that the results obtained with the auxiliary rudders at neutral are similar to those reported in reference 1 for the XF7U-1 model when consideration is given to the fact that small lateral deflections of the stick on the F7U-3 generally produce an aileron deflection corresponding to a much larger lateral stick deflection of the XF7U-1. With ailerons deflected only $\frac{1}{3}$ against the spin and the elevator set to near full up (the criterion spin) the model spun rather flat and recovery attempted by reversal of the main rudders alone was very unsatisfactory, the rotation continuing for more than 9 turns after control reversal. Although not specifically tested, movement of the elevator down would not be expected to improve recoveries for this setting of the ailerons, based on the recovery data presented in reference 1 for down settings of the elevator. Rapid recoveries were obtainable from the criterion spin, however, if rudder reversal was accompanied by simultaneous movement of the ailerons to full with the spin (stick right in a right spin), the model occasionally going into an aileron roll after termination of the spin. For full-against settings of the ailerons, the model spun flat and did not recover by reversal of the main rudders when the elevator was full up. When the elevator was neutral or down, ailerons full against the spin, a most unusual motion was obtained, the model appearing to cartwheel (rotate about the body Z axis) as it turned about a vertical axis, the model yawing to pilot's right for the right turning motion. A strip photograph of this motion is shown in figure 7. Although rudder reversal was not effective in terminating this latter motion, the motion was satisfactorily terminated by simultaneous reversal of rudder and movement of ailerons to full with the spin. Based on the results obtained, it appears that movement of the ailerons to full with the spin in addition to reversal of the rudder should be effective in terminating any spins or similar motions encountered on the airplane.

Only brief tests were conducted with the auxiliary rudders set full against the spin, these being for the criterion spin-control configuration. These results show that the model recovered from the criterion spin in the maximum allowable number of turns $\left(2\frac{1}{4}\right)$ by movement of the main rudders only. For the other settings of the ailerons and elevator, the recoveries from spins by movement of rudder or rudder and ailerons should be as good or better than those obtained with the auxiliary rudders at neutral. Tests with the auxiliary rudders set full with the spin indicate that the model would now spin with ailerons set at neutral in addition to spinning with ailerons set against the spin. Although reversal of the main rudders generally was not effective in terminating the spins the results indicate that simultaneous movement of ailerons to full with the spin and reversal of the rudders should still be effective in terminating the spins obtained.

On the airplane in the clean condition, the auxiliary rudders will probably automatically deflect to some position between neutral and full against the spin during spins (the auxiliary rudders provide automatic damping in yaw) and will probably not deflect with the spin unless something goes wrong with the automatic control system. Inasmuch as the model results indicated that the auxiliary rudders would have to be full against or near full against the spin for satisfactory recoveries to be obtainable by rudder reversal alone (or by rudder reversal followed by moving the elevator down), it appears that, in order to obtain satisfactory recovery on the airplane, full rudder reversal will have to be accompanied by movement of ailerons to full with the spin. It is recommended that this recovery procedure be used on the airplane. Although this movement of the controls may result in the airplane going into an aileron roll after termination of the spin, neutralization of the stick laterally should terminate the motion rapidly.

Effect of extending speed brakes and slats.- The effect on the model spin and recovery characteristics of extending speed brakes and slats is shown on chart 2 for the combat loading (loading point 1 on table III and fig. 5). As is indicated on the chart, extending the speed brakes had little effect on the spin and spin-recovery characteristics. Extending the slats, however, had a decided beneficial effect, the data indicating that even with the auxiliary rudders full with the spin recoveries from the criterion spin by reversal of the main rudders alone were satisfactory. It would appear therefore that satisfactory recoveries from spins of the airplane can be obtained without movement of the ailerons if provision is made for keeping the slats fully open during spins.

Effect of loading changes.- Results of tests conducted with the model loaded to simulate full rocket pack and auxiliary wing fuel installation for the take-off loading condition, the model in the clean condition, (loading number 2 on table III and fig. 5) are shown on chart 3. This loading condition is considered to be the most wing-heavy loading attainable on the airplane without disposable or jettisonable external stores attached to the wing. The results presented on chart 3 show that, for this loading, the model still did not spin when the ailerons were full with the spin and the results indicate that simultaneous reversal of the rudders and movement of ailerons to full with the spin should be effective in terminating the spins obtained. Although no specific tests were conducted with external stores (external fuel tanks and rockets) attached to the wings, based on the results obtained in the investigation reported in reference 1, it appears that the optimum control movement for recoveries from spins of the airplane for these loading conditions will be full rudder reversal and movement of ailerons to full with the spin. In the event recovery does not appear imminent, however, after a spin is entered with external stores attached, the external stores should be jettisoned and recovery should be reattempted.

Inverted Spins

The results of the inverted spin tests of the model in combat loading are presented in chart 4. The order used for presenting the data for the inverted spins is different from that used for erect spins. For inverted spins, controls crossed for the established spin (right rudder pedal forward and stick to pilot's left for a spin to the pilot's right) is presented to the right of the chart and stick back is presented at the bottom. When the controls are crossed in the established spin, the ailerons aid the rolling motion; when the controls are together, the ailerons oppose the rolling motion. The angle ϕ and the elevator position in the chart are given as up or down relative to the ground.

Results of model inverted spin tests indicate that satisfactory recoveries from inverted spins of the airplane should be obtained, even if the auxiliary rudders are full with the inverted spin, provided the main rudders are fully reversed and the stick is neutralized laterally and longitudinally. Neutralization of all controls was indicated to lead to satisfactory recoveries from inverted spins for neutral or against the spin positions of the auxiliary rudders.

Spin-Recovery Parachutes

The results of tests performed with spin-recovery parachutes attached to the outboard wing tip (left in a right spin) of the model presented in table IV show that a 6.12-foot-diameter parachute (measured laid out flat) with a towline length of 25 feet appears to be necessary for satisfactory recovery from spins of the airplane by parachute action alone. Although tested for the combat loading only, analysis indicates that this size parachute should be effective for emergency spin recovery for any loading condition obtainable on the airplane with external stores removed. Table IV indicates that the model generally recovered in a dive when the 6.12-foot parachute was opened for recovery, but that, when a much larger parachute was tested (10.5 feet, full scale, in diameter), it caused the model to spin at a rapid rate of rotation in the opposite direction after the parachute was opened for recovery. It thus appears that if a parachute is used for recovery, it should be released immediately after the original spin rotation ceases. The auxiliary rudders were at neutral for these tests. The drag coefficient of the 6.1-foot parachute was approximately 0.7 based on the area of the parachute when it is laid out flat. If a parachute with a different drag coefficient is used, a corresponding adjustment will be required in parachute size. Reference 5 indicates that conventional flat-type parachutes made of low-porosity materials are unstable and may seriously affect the stability of the airplane if the parachute is opened in normal flight to test its operation. It may be desirable, therefore, to use a stable parachute (reference 7) as an emergency spin-recovery device on the full-scale airplane.

Recommended Recovery Technique

Based on the results obtained with the model, the following recovery technique is recommended for all loadings and conditions of the airplane:

For erect spins, the ailerons should be moved to full with the spin (stick full right in a right spin) simultaneously with full rudder reversal to full against the spin, and approximately $\frac{1}{2}$ turn later the stick should be moved forward. This procedure may result in a rapid aileron roll; however, this roll can be terminated rapidly by movement of the ailerons to oppose the rolling motion. If recovery does not appear imminent after entry into a spin when external stores are installed, the external stores should be jettisoned and recovery should be reattempted in the manner prescribed.

For recovery from inverted spins, the rudder should be reversed briskly to full against the spin and the stick should be neutralized longitudinally and laterally.

CONCLUSIONS

Based on the results of tests of a $\frac{1}{21}$-scale model of the Chance Vought F7U-3 airplane, the following conclusions regarding the spin and recovery characteristics of the airplane at an altitude of 15,000 feet are made:

1. The spin-recovery characteristics of the airplane in the clean condition will be satisfactory for all loadings provided the following technique is used: brisk rudder reversal and simultaneous movement of the ailerons to full with the spin (stick right in a right spin) followed approximately $\frac{1}{2}$ turn later by forward movement of the stick. After the spin rotation ceases the stick should be neutralized laterally. The same recovery technique should be employed with external stores installed; however, if recovery does not appear imminent, the external stores should be jettisoned and recovery reattempted.

2. Extending the slats will have a favorable effect; whereas extending the speed brakes will have no appreciable effect on recoveries.

3. A 6.12-foot-diameter (laid out flat) wing-tip parachute attached to the outboard wing tip (left in a right spin) having a drag coefficient of 0.7 (based on laid-out-flat area) will be effective for emergency recovery from demonstration spins.

4. Satisfactory recoveries from inverted spins will be obtained by full reversal of the rudders and lateral and longitudinal neutralization of the stick.

Langley Aeronautical Laboratory
National Advisory Committee for Aeronautics
Langley Field, Va.

Walter J. Klinar
Walter J. Klinar
Aeronautical Research Scientist

Frederick M. Healy
Frederick M. Healy
Aeronautical Aerodynamic Research Intern

Approved: Thomas A. Harris
Thomas A. Harris
Chief of Stability Research Division

mjw

REFERENCES

1. Berman, Theodore, and Pumphrey, Norman E.: Investigation of the Spin and Recovery Characteristics of a 0.057-Scale Model of the Modified Chance Vought XF7U-1 Airplane TED NO. NACA DE 311. NACA RM SL50F02, Bur. Aero., 1950.

2. Daughtridge, Lee T., Jr.: Free-Spinning-Tunnel Tests of a 0.057-Scale Model of the Chance Vought XF7U-1 Airplane. NACA RM SL8A13, Bur. Aero., 1948.

3. Berman, Theodore: Supplementary Investigation in the Langley 20-Foot Free-Spinning Tunnel of the Spin and Recovery Characteristics of a 0.057-Scale Model of the Chance Vought XF7U-1 Airplane TED NO. NACA DE 311. NACA RM SL9H30a, Bur. Aero., 1949.

4. Zimmerman, C. H.: Preliminary Tests in the N.A.C.A. Free-Spinning Wind Tunnel. NACA Rep. 557, 1936.

5. Berman, Theodore: Comparison of Model and Full-Scale Spin Test Results for 60 Airplane Designs. NACA TN 2134, 1950.

6. Neihouse, A. I.: A Mass-Distribution Criterion for Predicting the Effect of Control Manipulation on the Recovery from a Spin. NACA ARR, Aug. 1942.

7. Scher, Stanley H., and Draper, John W.: The Effects of Stability of Spin-Recovery Tail Parachutes on the Behavior of Airplanes in Gliding Flight and in Spins. NACA TN 2098, 1950.

TABLE I.- DIMENSIONAL CHARACTERISTICS OF THE

CHANCE VOUGHT F7U-3 AIRPLANE

Over-all length, ft	43.79
Wing:	
Span, ft	39.72
Area, sq ft	535.3
Aspect ratio	2.94
Root chord, in.	194.06
Tip chord, in.	128.57
Mean geometric chord, in.	164.22
Leading edge $\bar{c}$ rearward leading edge root chord, in.	86.51
Taper ratio	0.66
Incidence (constant)	0
Dihedral, deg	0
Sweepback of quarter-chord line, deg	35
Airfoil section	CVA 4-(00)-(12)-(40)-(1.1)-(1.0)
Ailavator:	
Span, (b/2) percent	47.2
Total area, sq ft	74.36
Chord, percent $\bar{c}$	28.1
Vertical tail:	
Total area, sq ft	156.3
Rudder area, aft hinge line, sq ft	12.9
Auxiliary rudders, sq ft	11.9
Speed brake area, sq ft	24.8
Aspect ratio	1.45
Sweepback, quarter-chord line, deg	45
Airfoil section	NACA 64_1-008.9 (modified)
Slats:	
Span, (b/2) percent	
Inboard	28.9
Outboard	47.3

NACA

TABLE II.- CONDITIONS INVESTIGATED ON $\frac{1}{21}$-SCALE MODEL OF THE CHANCE VOUGHT F7U-3 AIRPLANE

Loading condition	Loading number	Type spin	Slats	Speed brakes	Auxiliary rudders	Method employed in recovery attempt	Data pre- sented in
Combat	1	Erect	Retracted	Retracted	Neutral	Movement of controls	Chart 1
Do------	1	---do---	---do----	---do----	Full with	---------do---------	Do.
Do------	1	---do---	---do----	---do----	Full against	---------do---------	Do.
Do------	1	---do---	---do----	Extended	Neutral	---------do---------	Chart 2
Do------	1	---do---	Extended	Retracted	Full with	---------do---------	Do.
Take-off with overload fuel and rocket pack	2	---do---	Retracted	---do----	Neutral	---------do---------	Chart 3
Do------	2	---do---	---do----	---do----	Full with	---------do---------	Do.
Do------	2	---do---	Extended	---do----	Neutral	---------do---------	Do.
Combat	1	Inverted	Retracted	---do----	Full with	---------do---------	Chart 4
Do------	1	---do---	---do----	---do----	Neutral	---------do---------	Do.
Combat	1	Erect	---do----	---do----	-----do-----	Parachute opening	Table IV

NACA

TABLE III.- MASS CHARACTERISTICS AND INERTIA PARAMETERS FOR LOADINGS POSSIBLE ON THE CHANCE VOUGHT F7U-3 AIRPLANE AND FOR LOADINGS TESTED ON THE $\frac{1}{21}$-SCALE MODEL

[Model values are given as corresponding full-scale values; moments of inertia are given about the center of gravity]

No.	Loading	Weight (lb)	Center-of-gravity location		Relative density μ		Moments of inertia (slug-feet^2)			Mass Parameters		
			$x/\bar{c}$	$z/\bar{c}$	Sea level	15,000 feet	I_X	I_Y	I_Z	$\frac{I_X - I_Y}{mb^2}$	$\frac{I_Y - I_Z}{mb^2}$	$\frac{I_Z}{m}$
					Airplane values							
1	Combat, landing gear retracted	24,656	0.126	-0.0104	15.14	24.07	24,097	45,161	67,228	-174×10^{-4}	-183×10^{-4}	357
2	Take off with overload fuselage fuel and fuselage rocket pack	30,547	0.106	-0.0111	18.76	29.82	34,303	52,137	83,569	-119	-210	329
3	Take off, landing gear extended	28,244	0.138	-0.0023	17.35	27.57	30,356	49,118	76,808	-136	-200	336
4	Take off, landing gear retracted	28,244	0.151	-0.0137	17.35	27.57	29,927	49,118	76,936	-139	-201	340
5	Take off with overload fuel and two 150-gal center section tanks	31,888	0.115	-0.0017	19.59	31.13	34,769	51,812	83,512	-109	-203	312
6	Take off with two 2,000-lb bombs	32,891	0.126	0.0101	20.20	32.10	36,566	50,529	83,489	- 87	-205	292
7	Take off with four Sparrows	31,391	0.134	-0.0047	19.30	30.70	38,120	51,893	87,469	- 89	-231	320
8	Take off with fuselage rocket pack	29,801	0.136	-0.0038	18.30	29.09	32,398	49,990	79,455	-120	-202	322
9	Take off with overload fuel, two inboard tanks, two Sparrows, and rocket pack	33,998	0.119	0.0105	20.88	33.19	39,160	52,473	87,621	- 80	-211	291
10	Landing condition, landing gear extended	22,862	0.117	-0.0077	14.04	22.32	23,955	43,750	64,525	-177	-185	362
					Model values							
1	Combat	24,640	0.129	-0.0150	15.14	24.07	25,311	46,285	67,721	-174×10^{-4}	-178×10^{-4}	352
2	Take off with overload fuselage fuel and fuselage rocket pack	30,553	0.106	0.0124	18.78	29.85	34,201	53,710	81,410	-130	-185	315

NACA

TABLE IV.- WING-TIP SPIN-RECOVERY PARACHUTE DATE OBTAINED WITH THE $\frac{1}{21}$-SCALE MODEL OF THE CHANCE VOUGHT F7U-3 AIRPLANE

[Combat loading (loading 1 in table III; recovery attempted by opening parachute from left wing tip; right erect spins; control setting for steady spin - elevators $\frac{2}{3}$ up, ailerons $\frac{1}{3}$ against, rudder full with spin, auxiliary rudders neutral; model values have been converted to corresponding full scale values.]

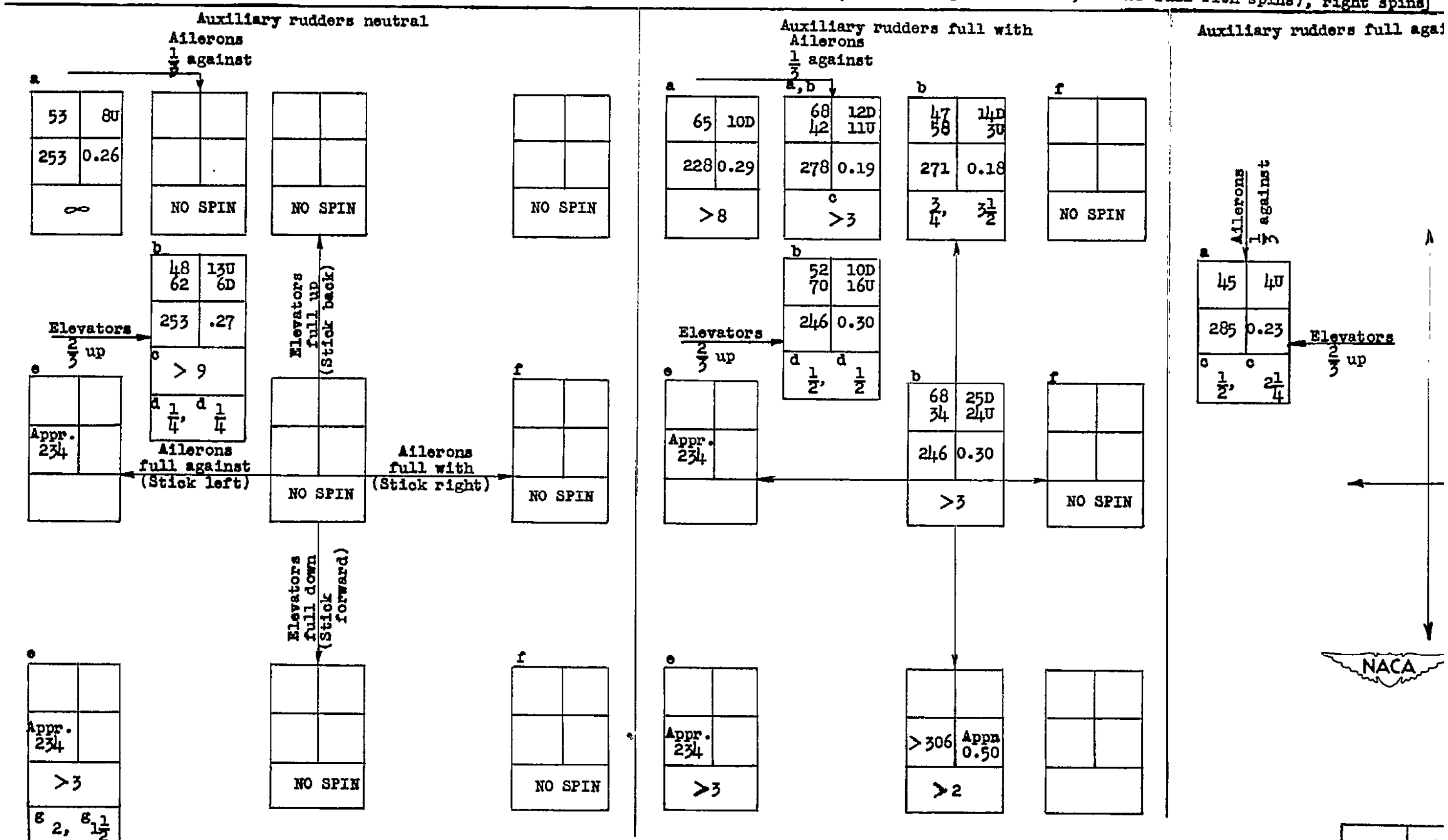
Parachute Diameter (ft)	Towline Length (ft)	Approximate Parachute Drag Coefficient	Turns For Recovery
3.5	4.2	0.76	>5
3.5	25.0	--	>6
5.25	25.0	--	1, >5, $5\frac{1}{2}$
6.12	25.0	0.70	$\frac{1}{2}$, $\frac{1}{2}$, $\frac{1}{2}$, $\frac{1}{2}$, 1
7.0	25.0	--	[a] $\frac{1}{2}$, [a] $\frac{1}{2}$, [a] $\frac{3}{4}$
8.75	25.0	--	[a] $\frac{1}{4}$
10.5	25.0	0.77	[b] $\frac{1}{2}$, [b] $\frac{1}{4}$, [b] $\frac{1}{4}$

NACA

[a]Parachute yawed model in opposite direction.
[b]Parachute caused model to spin in opposite direction.

CHART 1.- ERECT SPIN AND RECOVERY CHARACTERISTICS OF THE MODEL IN THE COMBAT LOADING AND CLEAN CONDITION

[Model loading 1 in table III; auxiliary rudder position as indicated; speed brakes and slats retracted; recovery attempted by full rapid rudder reversal except as indicated (recovery attempted from, and steady-spin data presented for, rudder full with spins), right spins]



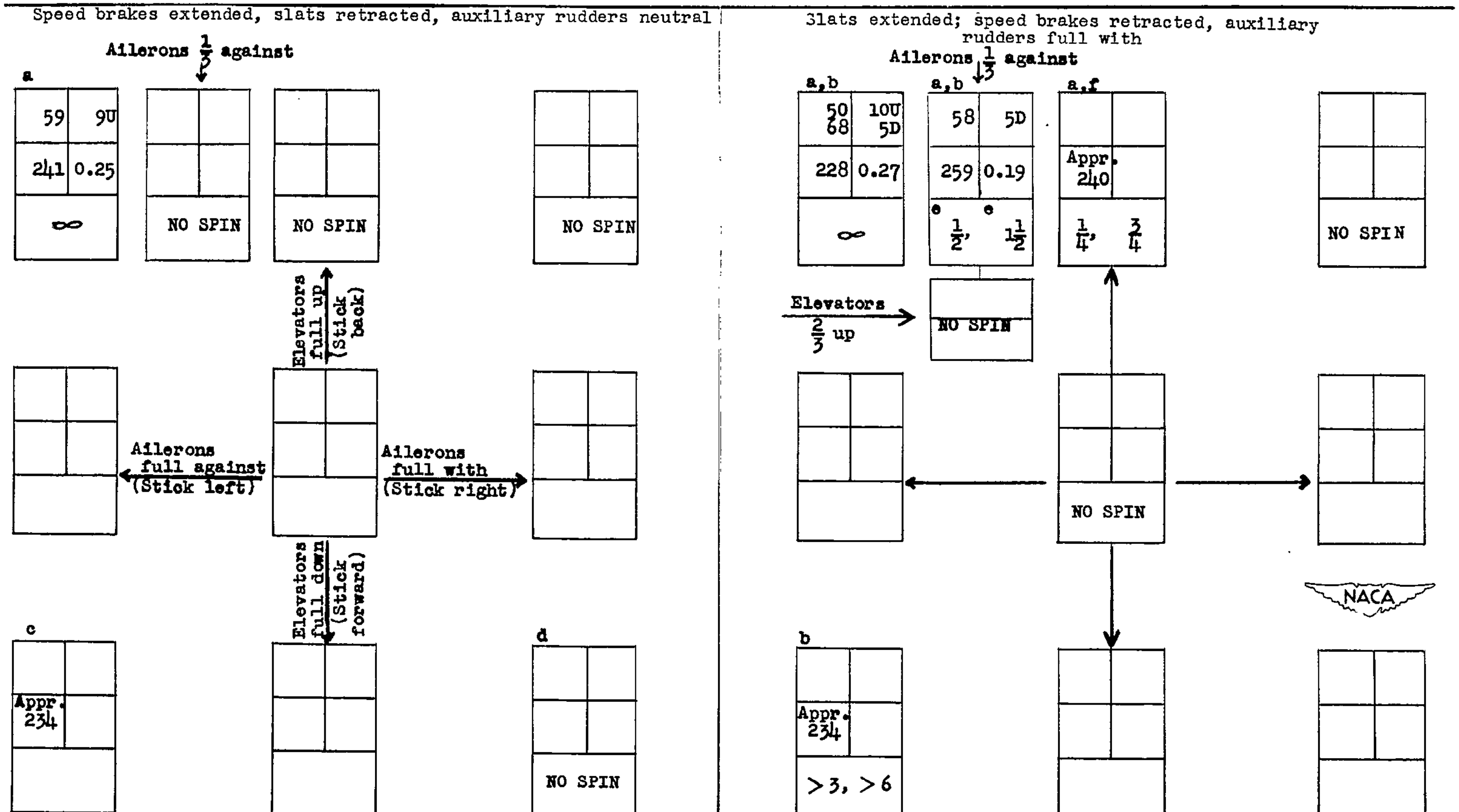
[a]No-spin condition also obtained.
[b]Oscillatory spin, range of values given.
[c]Recovery attempted by reversal of rudder to only $\frac{2}{3}$ of its full deflection against the spin.
[d]Recovery attempted by reversal of rudder to $\frac{2}{3}$ of its full deflection against the spin and simultaneous movement of ailerons to full with the spin. Sometimes model goes into aileron roll after termination of spin.
[e]Model appears to cartwheel as it rotates about a vertical axis, the rotations being in the same sense. (See fig. 7.) Sometimes motion stops and model goes into a left roll or an inverted spin.
[f]Model enters an aileron roll after cessation of imparted launching rotation.
[g]Recovery attempted by full rudder reversal and simultaneous movement of ailerons to full with the spin.

Model values converted to corresponding full-scale values.
U inner wing up
D inner wing down

α (deg)	φ (de
V (fps)	Ω (rp
Turns for recovery	

CHART 2.- EFFECT OF SLATS AND SPEED BRAKES ON THE ERECT SPIN AND RECOVERY CHARACTERISTICS OF THE MODEL

[Model Loading 1 in table III; position of slats, speed brakes, and auxiliary rudders as indicated; recovery attempted by full rapid rudder reversal except as indicated (recovery attempted from and steady-spin data presented for, rudder full with spins), right spins]



[a]A no-spin condition also obtained.

[b]Oscillatory spin, range of values given.

[c]Model appears to cartwheel as it rotates about a vertical axis, the rotation being in the same sense. (See fig. 7.) Sometimes motion stops and model goes into a left roll or inverted spin.

[d]Model goes into an aileron roll after cessation of the imparted launching rotation.

[e]Recovery attempted by reversal of rudder to only 2/3 of its full deflection against the spin.

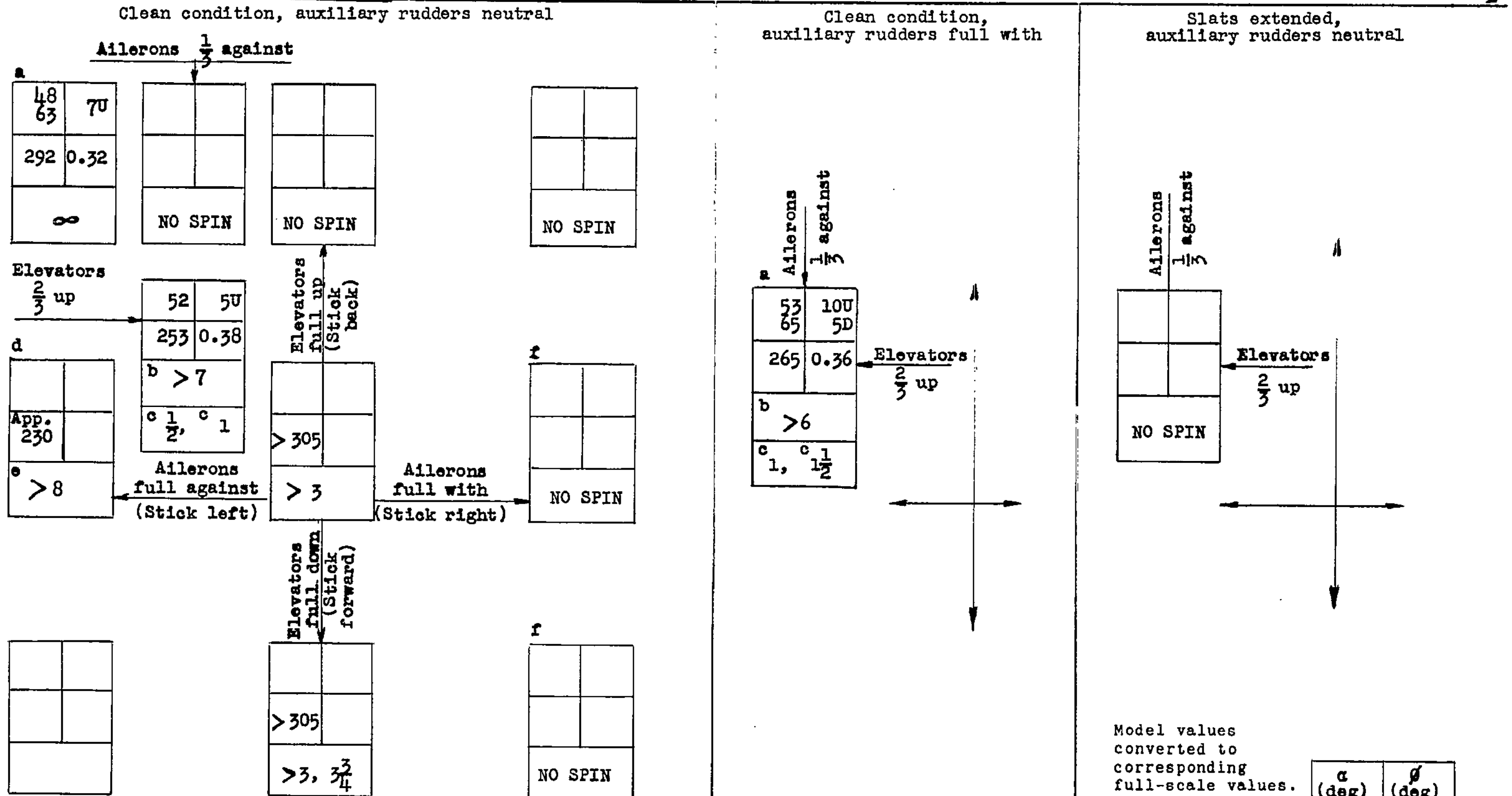
[f]Wide radius spin with oscillations in roll.

Model values converted to corresponding full-scale values.
U inner wing up
D inner wing down

α (deg)	ϕ (deg)
V (fps)	Ω (rps)
Turns for recovery	

CHART 3.- ERECT SPIN AND RECOVERY CHARACTERISTICS OF THE MODEL IN THE TAKE-OFF LOADING WITH OVERLOAD FUEL AND ROCKET PACK

[Model loading 2 in table III; position of slats and auxiliary rudders as indicated; speed brakes retracted; recovery attempted by full rapid rudder reversal except as indicated (recovery attempted from, and steady-spin data presented for, rudder full with spins), right spins]



[a]Oscillatory spin, range of values given.
[b]Recovery attempted by reversal of rudders to only 2/3 of their full deflection against the spin.
[c]Recovery attempted by reversal of rudders to 2/3 of their full deflection against the spin and simultaneous movement of ailerons to full with the spin. Sometimes model goes into aileron roll after termination of spin.
[d]Model appears to cartwheel as it rotates about a vertical axis, the rotations being in the same sense. (See fig. 7.)
[e]Visual observation.
[f]Model goes into an aileron roll after cessation of imparted launching rotation.

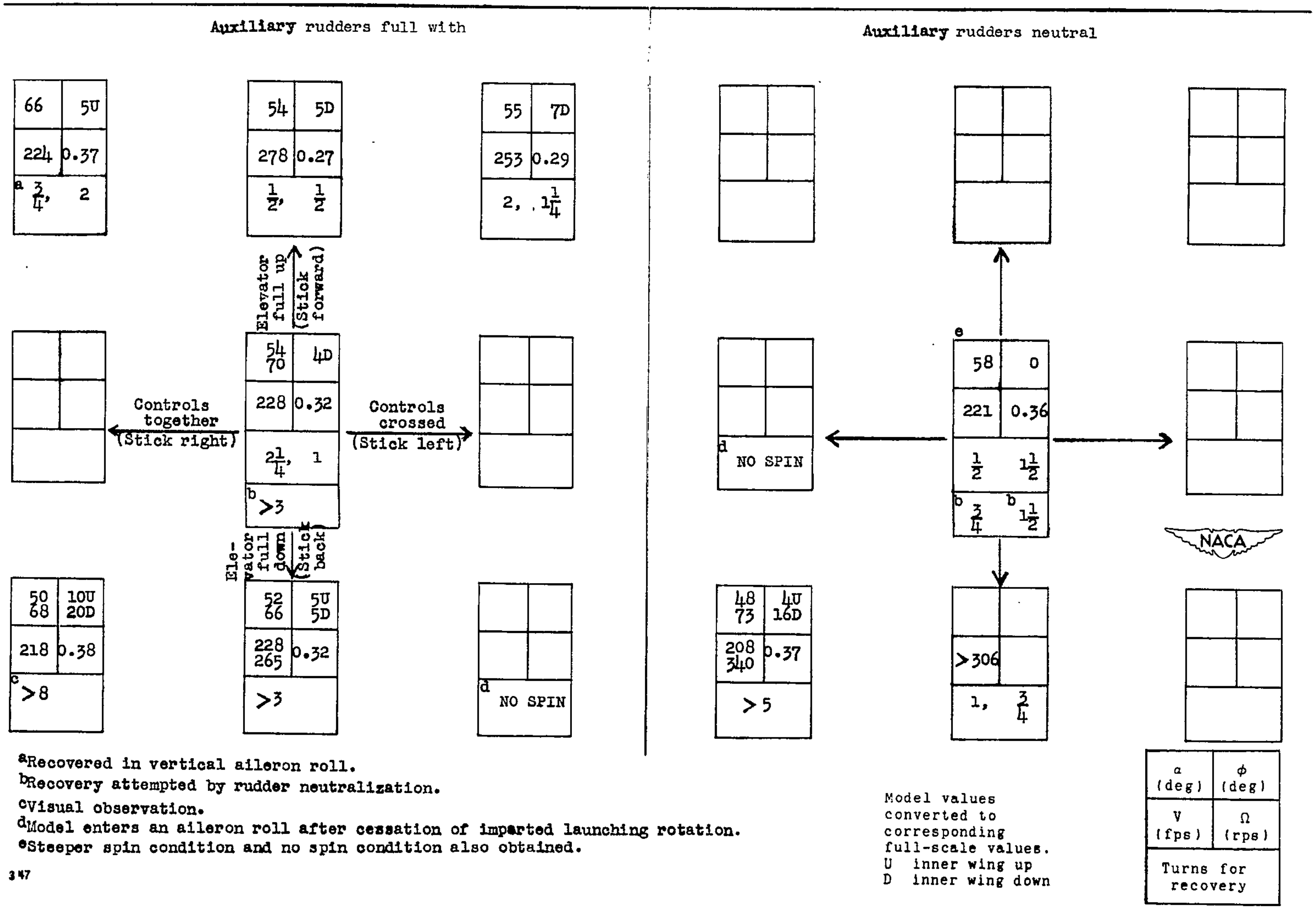
[redacted]

[redacted]

NACA

CHART 4.- INVERTED SPIN AND RECOVERY CHARACTERISTICS OF THE MODEL

[Model Loading 1 in table III; auxiliary rudders as indicated; speed brakes and slats retracted; recovery attempted by full rapid rudder reversal except as indicated (recovery attempted from, and steady-spin data presented for, rudder full with spins), right spins]



[a]Recovered in vertical aileron roll.
[b]Recovery attempted by rudder neutralization.
[c]Visual observation.
[d]Model enters an aileron roll after cessation of imparted launching rotation.
[e]Steeper spin condition and no spin condition also obtained.

347

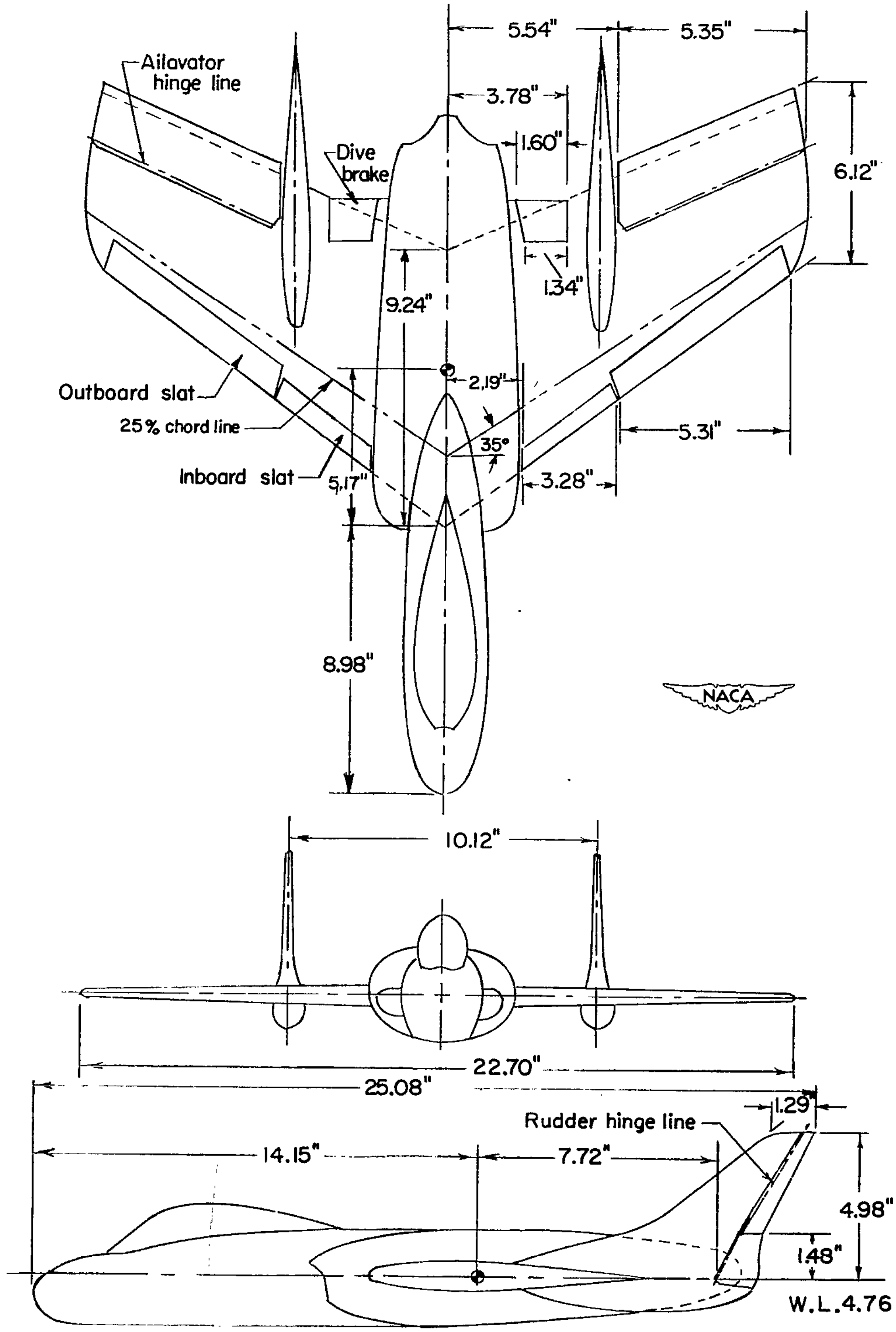


Figure 1.- Drawing of model as tested. Center-of-gravity position shown for combat loading.

[redacted]

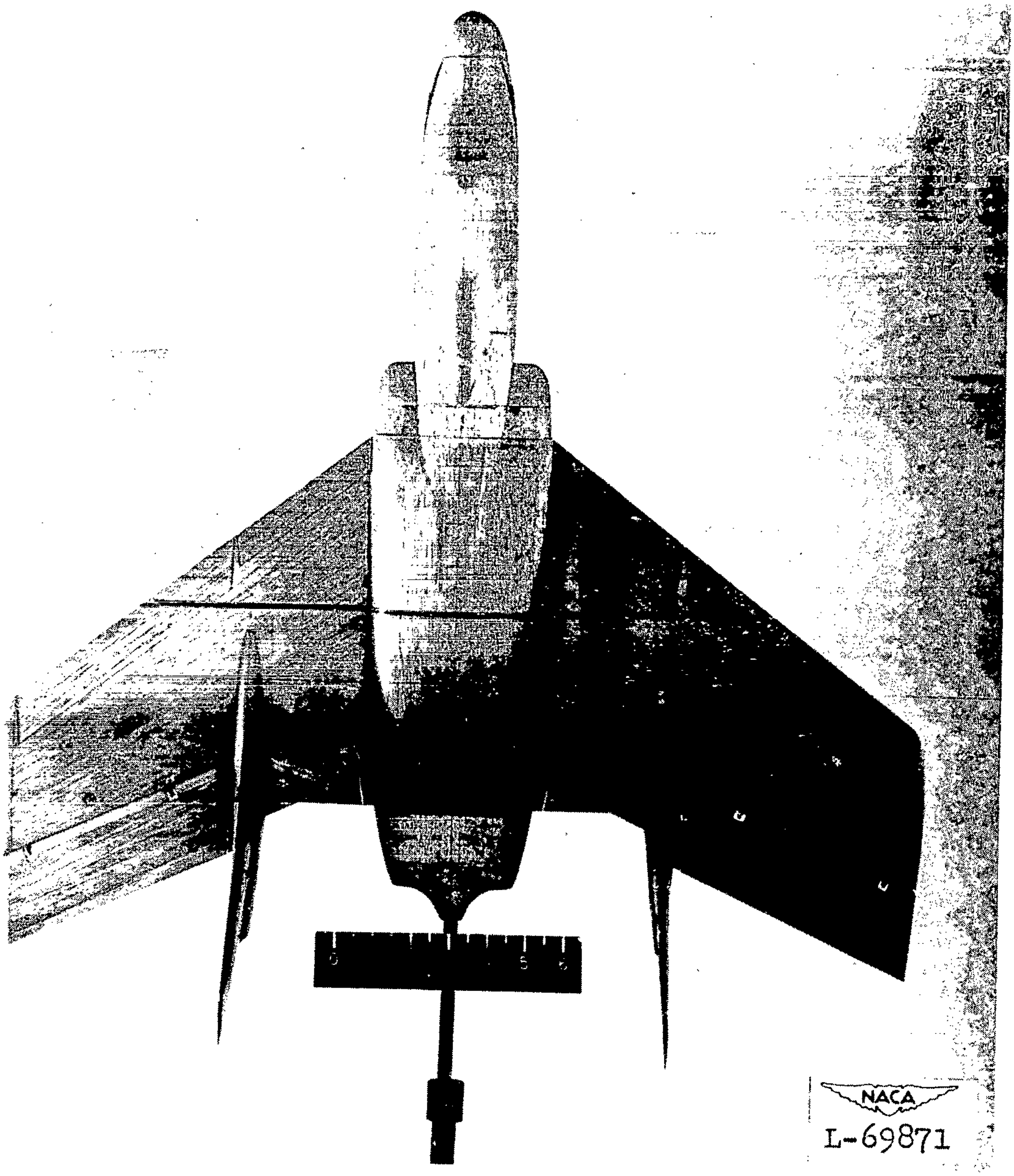


Figure 2.- Photograph of model in the clean condition.

[redacted]

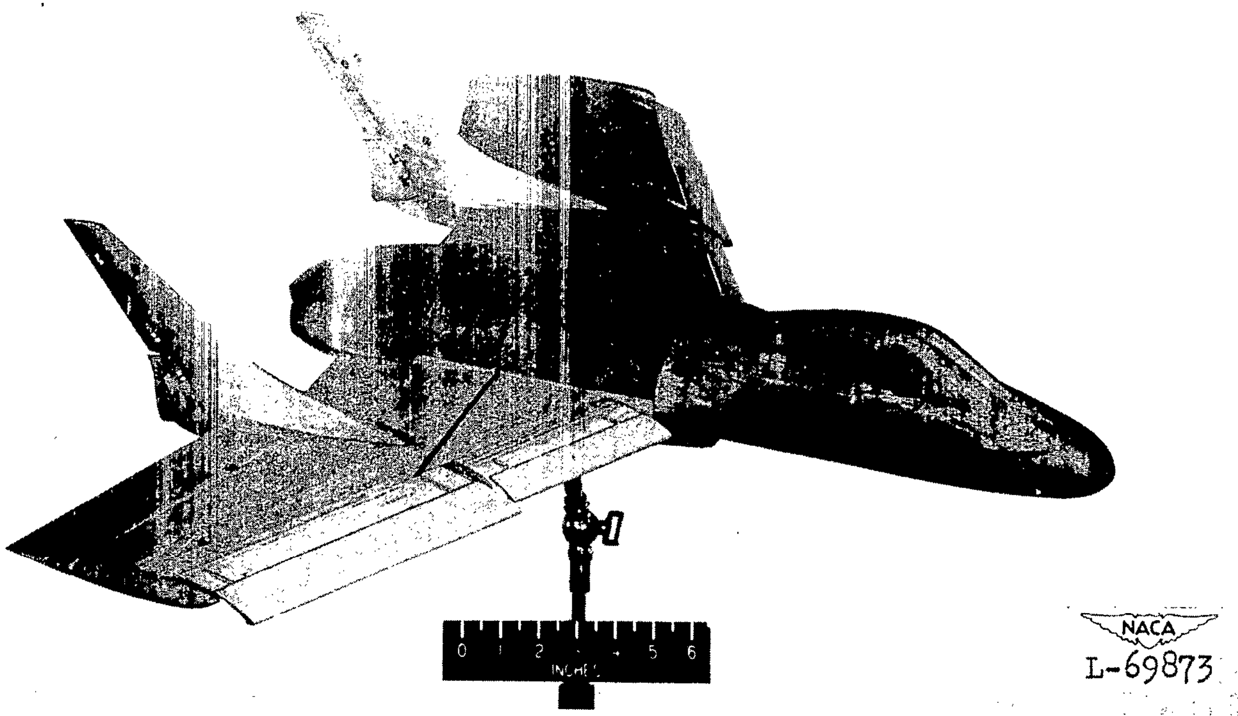


Figure 3.- Photograph of model showing the slats extended.

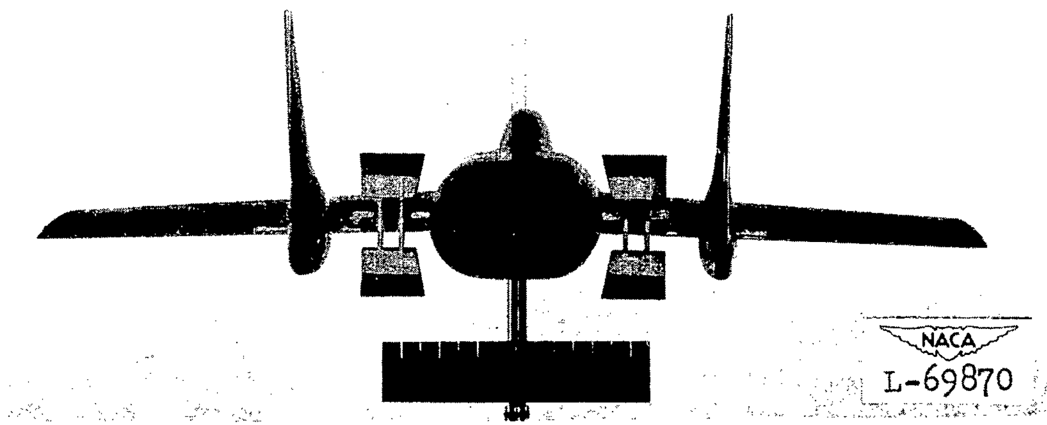


Figure 4.- Rear-view photograph of model showing speed brakes extended.

[redacted]

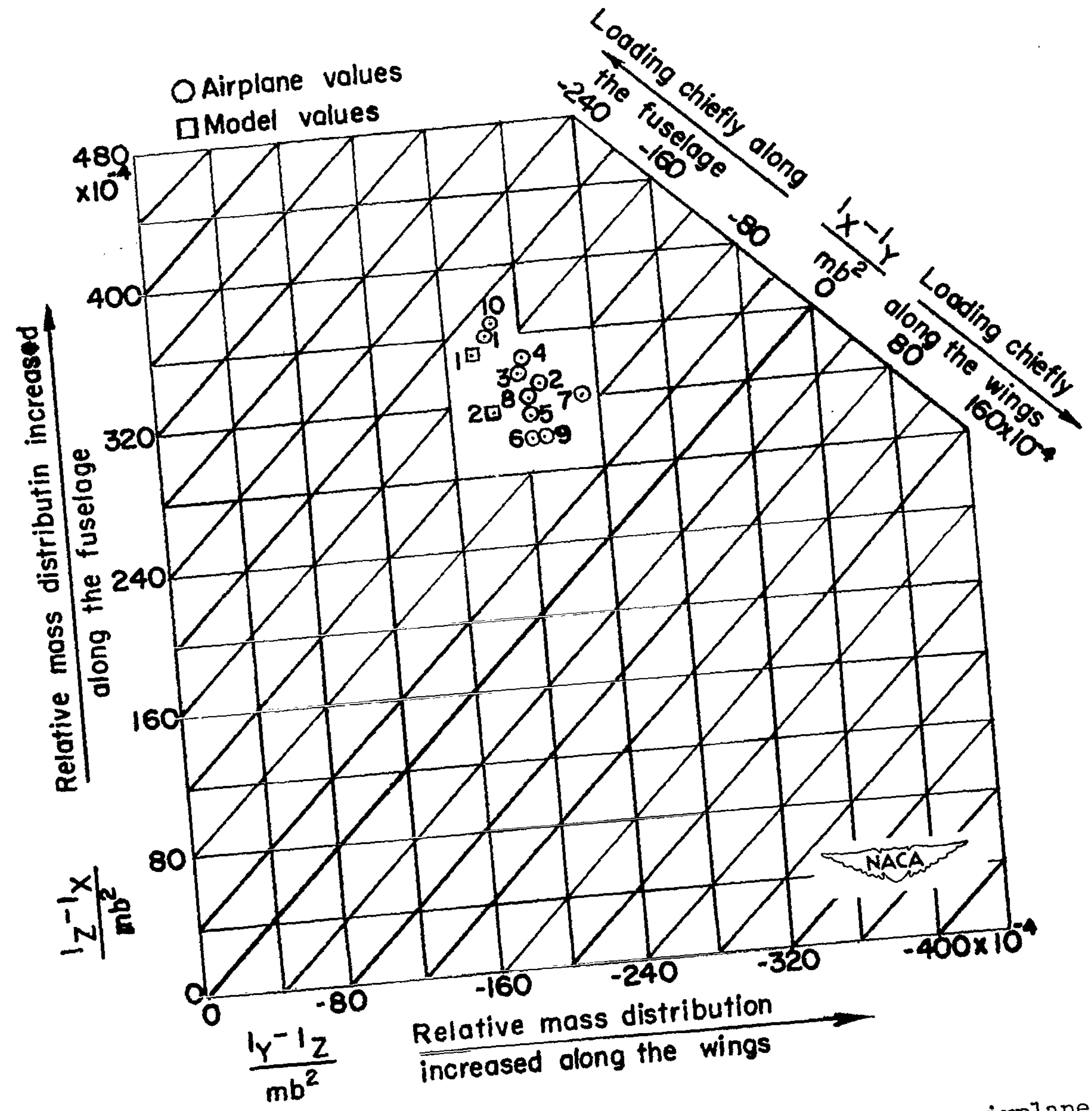


Figure 5.- Inertia parameters for loadings possible on the airplane and for the loadings tested on the model (points for loadings listed in table III).

[redacted]

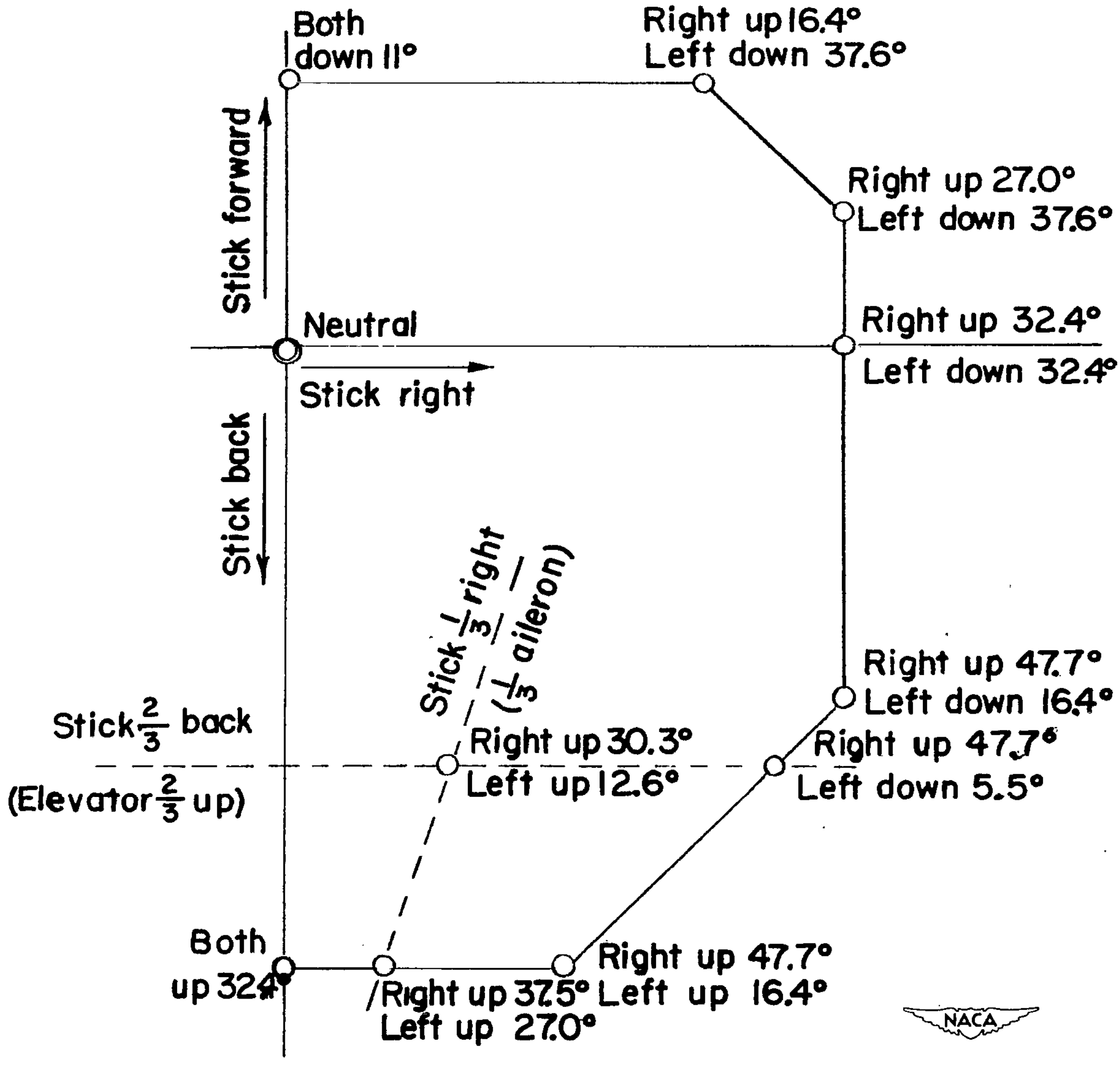
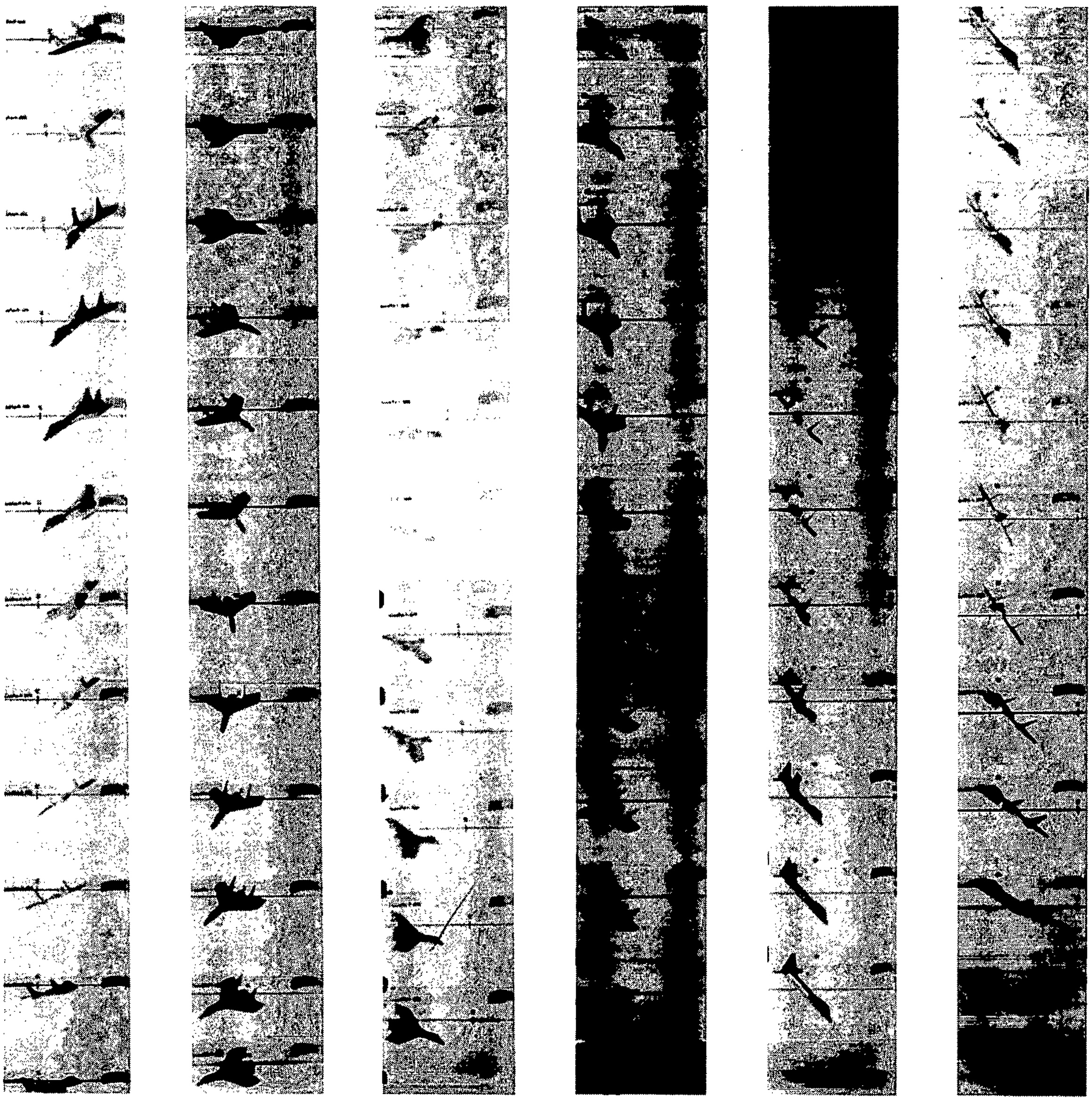


Figure 6.- Deflection of ailavator surfaces relative to control stick motion. Envelope of stick and ailavator movements shown. Ailavator position is directly proportional to control stick position; angles are measured in plane normal to hinge center line; stick travel to right is shown, left travel is symmetrical.



L-70830

Figure 7.- Strip photograph illustrating the motions encountered with ailerons against the spin, elevator neutral or down. Pictures taken at 64 frames per second.

 [redacted]

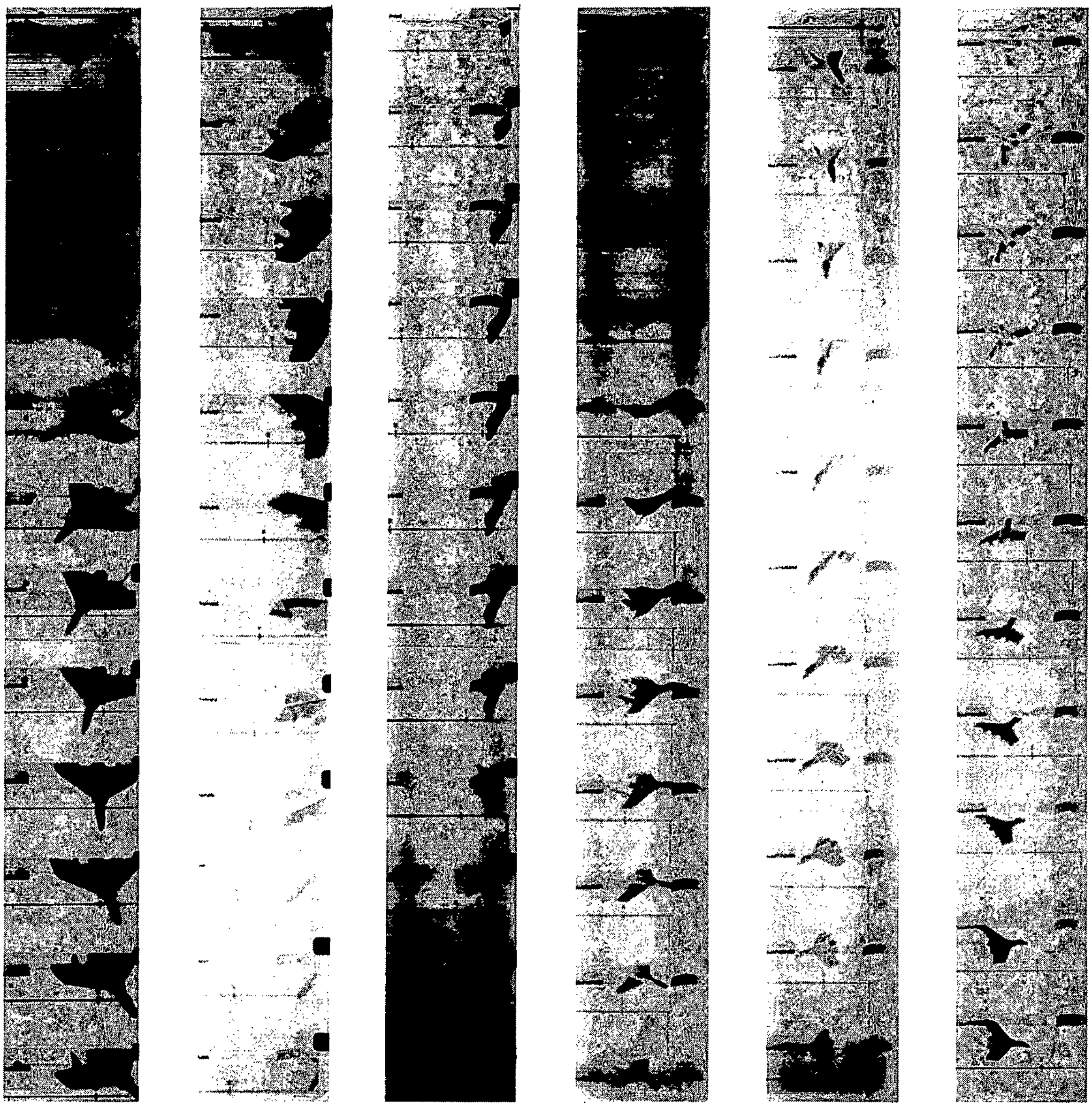


Figure 7.- Continued.

L-70831

[redacted]

[redacted]

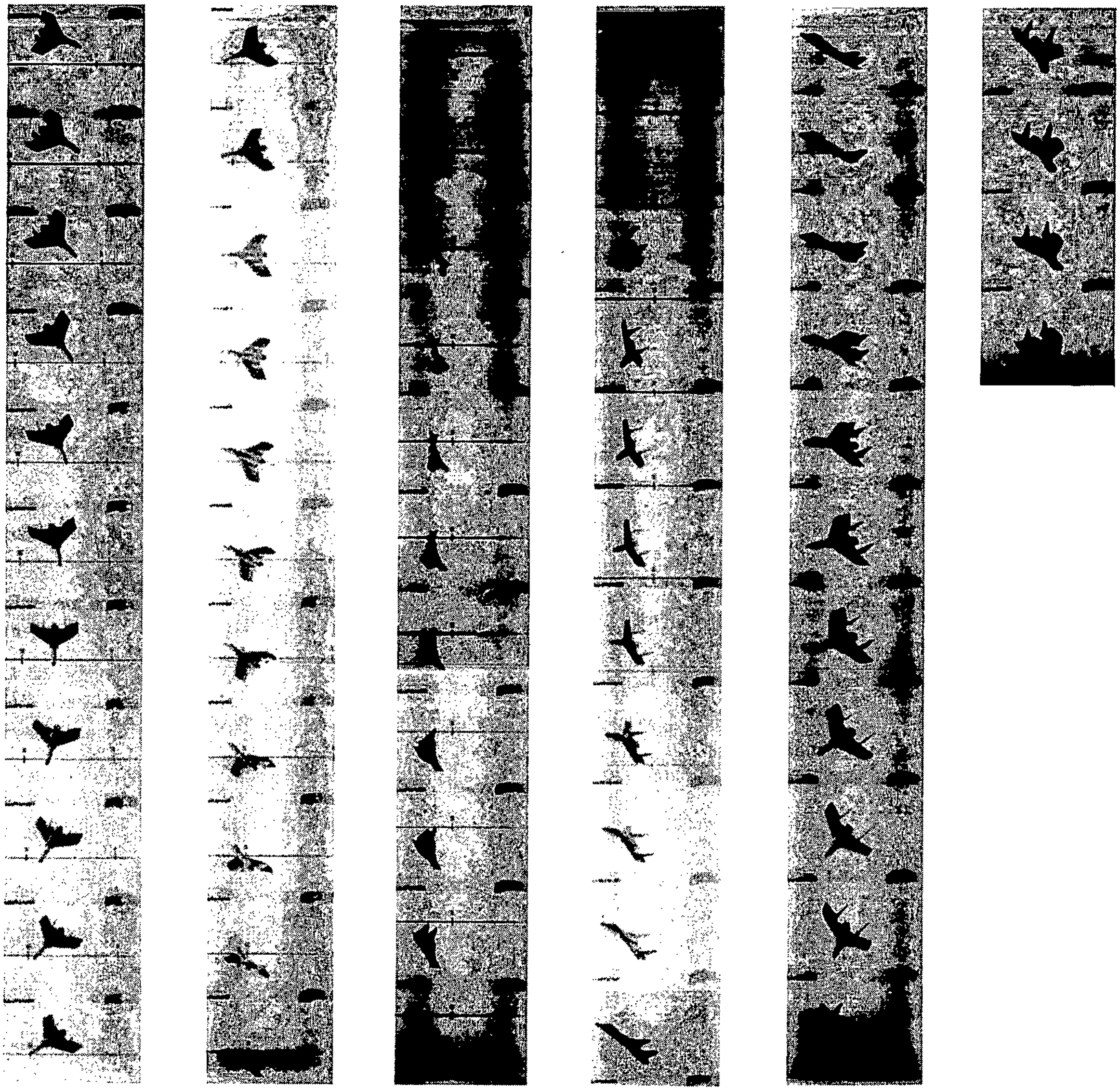


Figure 7.- Concluded.

L-70832

[redacted]

SECURITY INFORMATION

CONFIDENTIAL